Cambridge (CIE) AS Biology

Your notes

Cells as the Basic Units of Living Organisms

Contents

- Eukaryotic Cell Structures & Functions
- Animal & Plant Cells
- The Vital Role of ATP
- Prokaryotic v Eukaryotic Cells
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Eukaryotic Cell Structures & Functions

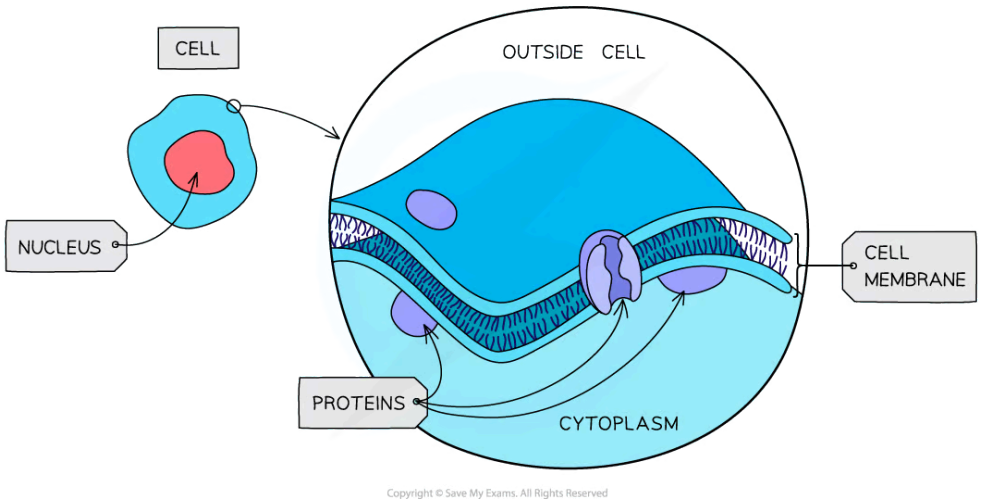
- Cells can be divided into two broad types; **eukaryotic** and **prokaryotic cells**
- Eukaryotic cells have a more complex ultrastructure than prokaryotic cells
  - The term ultrastructure refers to the internal structure of cells
- The cytoplasm of eukaryotic cells is divided up into membrane-bound compartments called **organelles**

Cell organelles

Cell surface membrane

- All cells are surrounded by a cell surface membrane which separates the inside of cells from their surroundings
- Cell surface membranes **controls the exchange of materials** between the internal cell environment and the external environment
  - The membrane is described as being partially permeable as it allows the passage of some substances and not others
- The cell membrane is formed from a **phospholipid bilayer** and spans a diameter of around 10 nm

Cell surface membrane diagram



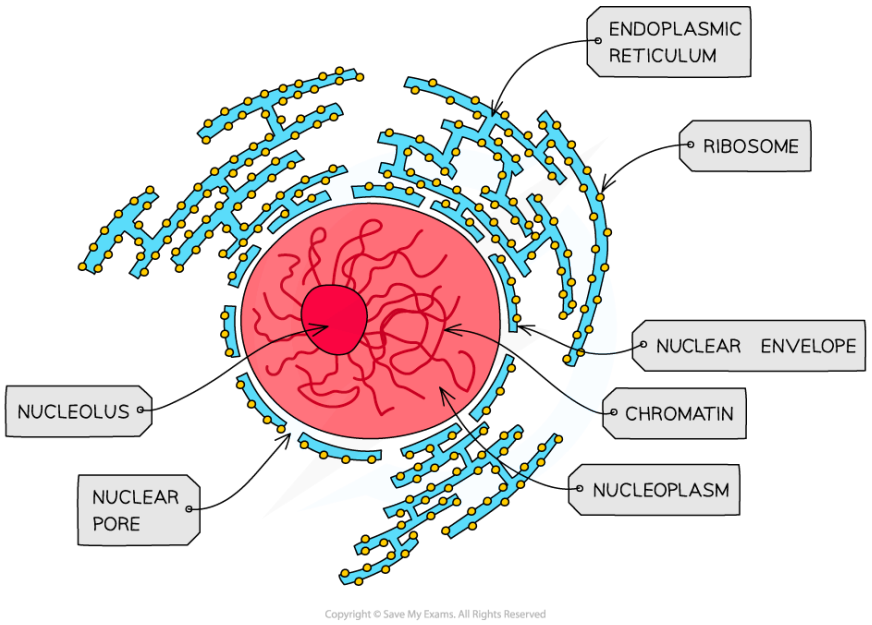
Cell surface membranes separate cell contents from the surrounding environment and control the passage of substances into and out of cells

Nucleus

- Present in all eukaryotic cells, the nucleus is a large organelle that is separated from the cytoplasm by a double membrane
- The nucleus contains the **DNA**, which is arranged into chromosomes
  - Chromosomes contain DNA and proteins, which are collectively referred to as chromatin
- The nuclear membrane is known as the **nuclear envelope**, and contains many **pores**
- **Nuclear pores** are important channels for allowing mRNA and ribosomes to travel out of the nucleus, as well as allowing enzymes and signalling molecules to move in
- The nucleus contains a region known as the **nucleolus**, which is the site of ribosome production

Your notes

Nucleus diagram



The nucleus of a cell contains the genetic material

Rough & smooth endoplasmic reticulum

- The endoplasmic reticulum (ER) is made up of a **series of membranes** that form flattened sacs within the cell cytoplasm
- The ER is linked with the nuclear envelope
- There are two distinct types of ER, with different roles within the cell
  - The **rough endoplasmic reticulum (RER)**
    - Continuous folds of membrane that are linked with the **nuclear envelope**
    - The surface of the RER is covered in **ribosomes**
    - The role of the RER is to **process proteins** that are produced on the ribosomes

- The **smooth endoplasmic reticulum (SER)**
  - The SER does **not** have ribosomes on the surface
  - It is involved in the **production of lipids**, and of **steroid hormones** such as oestrogen and testosterone

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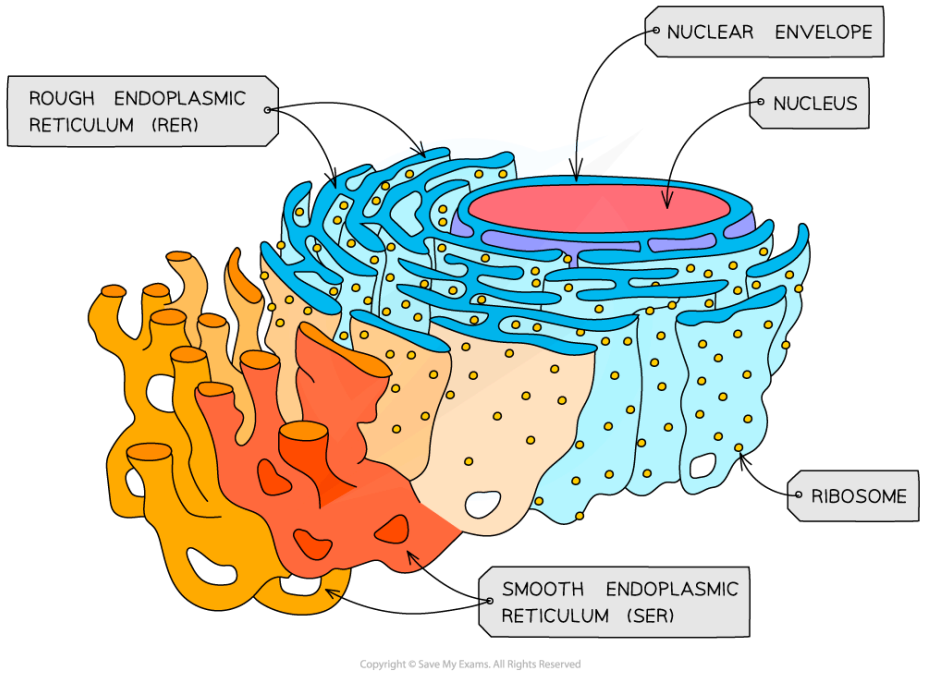
Rough and smooth endoplasmic reticulum diagram



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The RER has ribosomes on its outer surface and is continuous with the nuclear envelope, while the SER lacks ribosomes

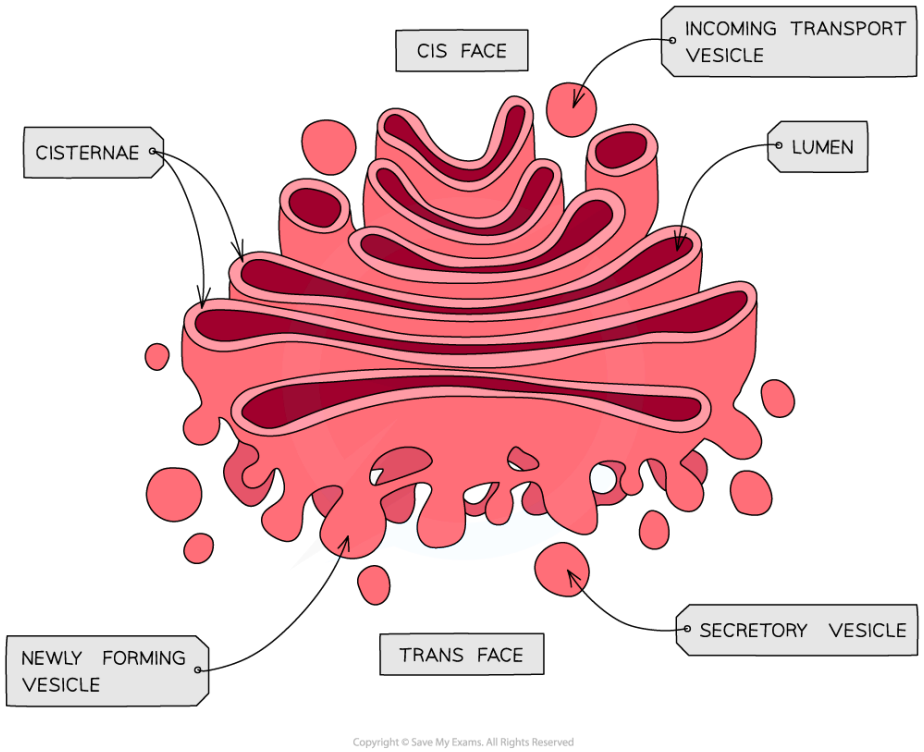
Examiner Tips and Tricks

Be sure to always use the full name of the rough and smooth endoplasmic reticulum when you first refer these structures in an exam; marks are often not awarded for the abbreviations RER and SER in the absence of the full key terms.

Golgi body

- The Golgi body is often referred to as the Golgi apparatus or the Golgi complex
- It consists of a **series of flattened sacs** of membrane
- It can be clearly distinguished from the ER, as it is not connected to other membrane-bound compartments, and it has a distinctive 'wifi symbol' appearance
- Its role is to **modify proteins** and **package** them into vesicles

Golgi body diagram



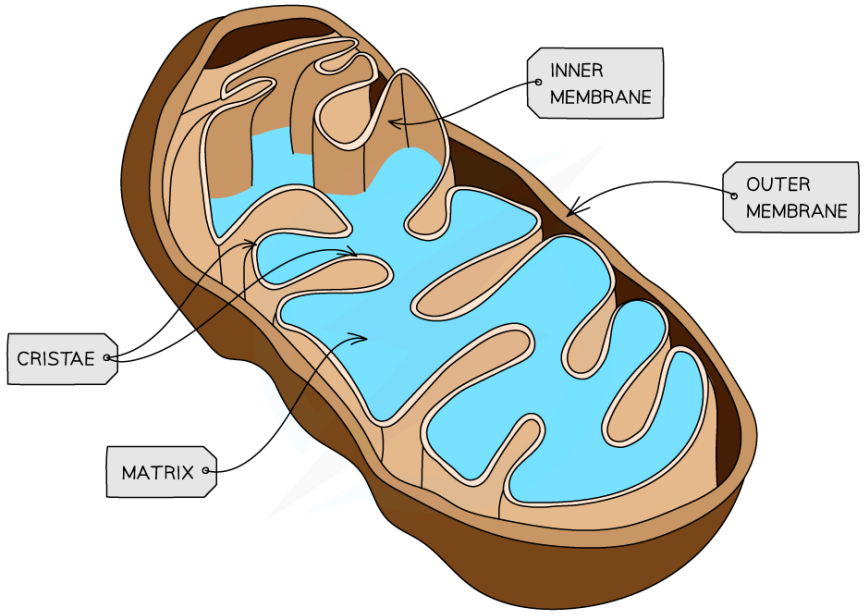
The Golgi body processes proteins and packages them into vesicles

Mitochondria

- Mitochondria (singular mitochondrion) are relatively large organelles surrounded by a double-membrane
  - They are smaller than the nucleus and chloroplasts, but can be seen with a light microscope
- The **inner membrane** is folded to form **cristae**
- Mitochondria are the **site of aerobic respiration** within eukaryotic cells
- The mitochondrial matrix contains **enzymes** needed for aerobic respiration
- Small, circular pieces of DNA, known as **mitochondrial DNA**, and ribosomes are also found in the matrix
  - This allows the production of proteins required for respiration

Mitochondria diagram

Your notes



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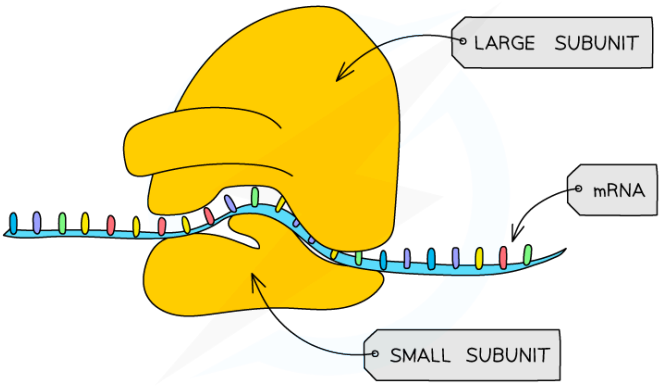
Mitochondria have a highly folded inner membrane; this provides a large surface area for embedded proteins that are involved with aerobic respiration

Ribosomes

- Ribosomes are found in the cytoplasm of all cells or as part of the **rough endoplasmic reticulum** in eukaryotic cells
- Each ribosome is a complex of **ribosomal RNA (rRNA)** and proteins
- 80S ribosomes (composed of 60S and 40S subunits) are found in eukaryotic cells
  - Smaller, 70S ribosomes (composed of 50S and 30S subunits) are found in prokaryotes, mitochondria and chloroplasts
- Ribosomes are the site of translation during **protein synthesis**

Ribosome diagram



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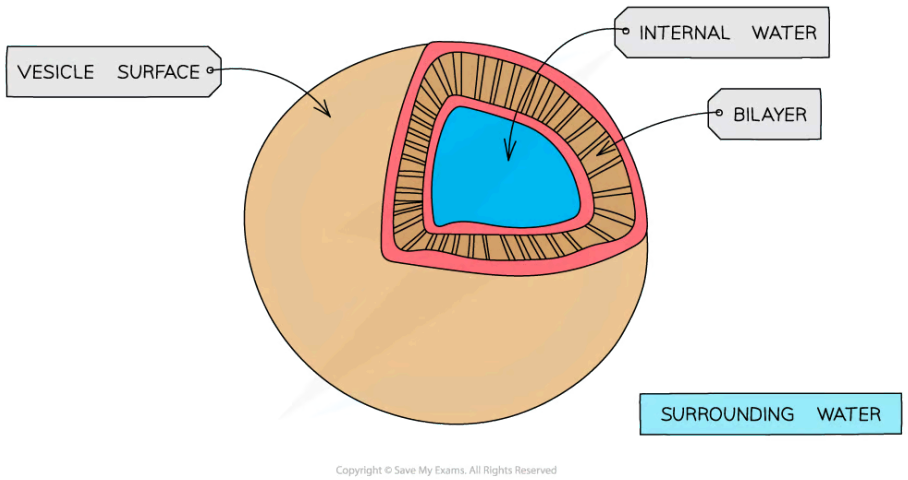
Ribosomes are formed in the nucleolus and are composed of almost equal amounts of RNA and protein

Your notes

Vesicles

- Vesicles are small, membrane-bound sacs used by cells for **transport** and **storage**
- They can be pinched off the ends of the Golgi body; these are known as **Golgi vesicles**
- They can fuse with the cell surface membrane to allow exocytosis, or bud from the membrane during endocytosis

Vesicle diagram



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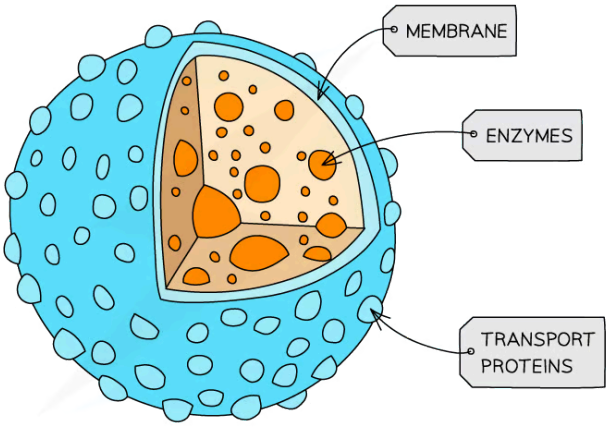
Vesicles carry out transport and storage of substances within cells

Lysosomes

- Lysosomes are specialised vesicles which contain **hydrolytic enzymes**
- Hydrolytic enzymes break down biological molecules, e.g.
  - Waste materials, such as worn-out organelles
  - Engulfed pathogens during phagocytosis
  - Cell debris during apoptosis (programmed cell death)

Lysosome diagram



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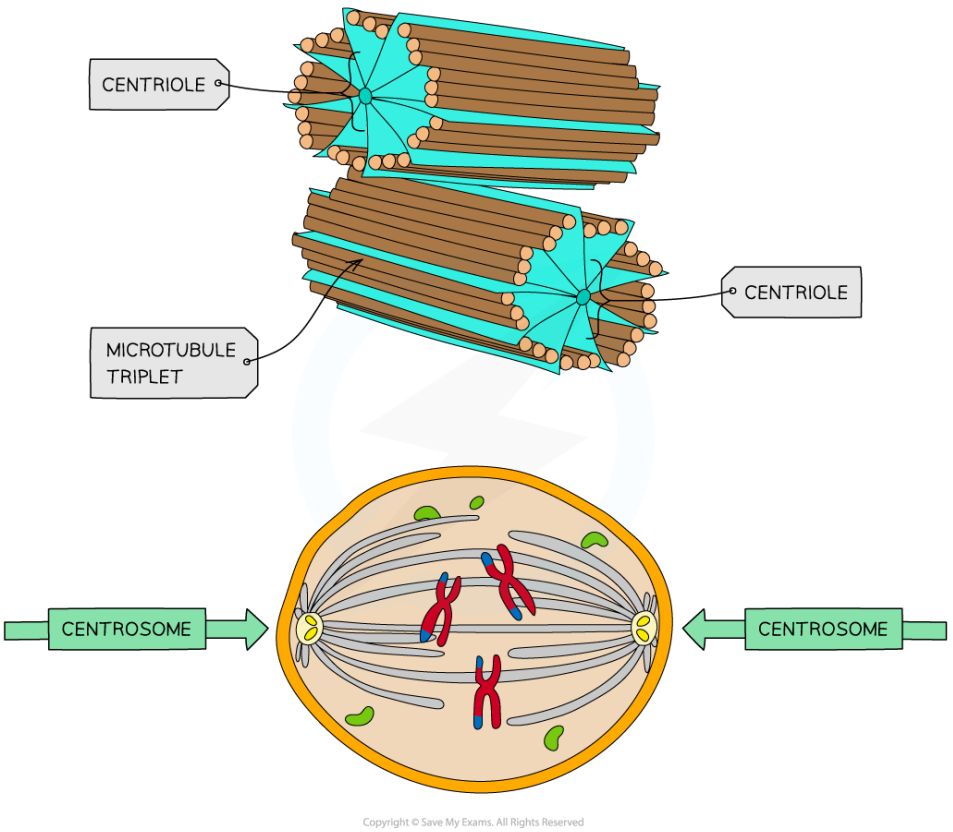
Lysosomes contain hydrolytic enzymes for the breakdown of biological molecules

Centrioles

- Centrioles are hollow fibres made of **microtubules**
- Two centrioles at right angles to each other form a **centrosome**, which organises the **spindle fibres** during cell division
- Note that centrioles are not found in flowering plants and fungi

Centrioles diagram

Your notes



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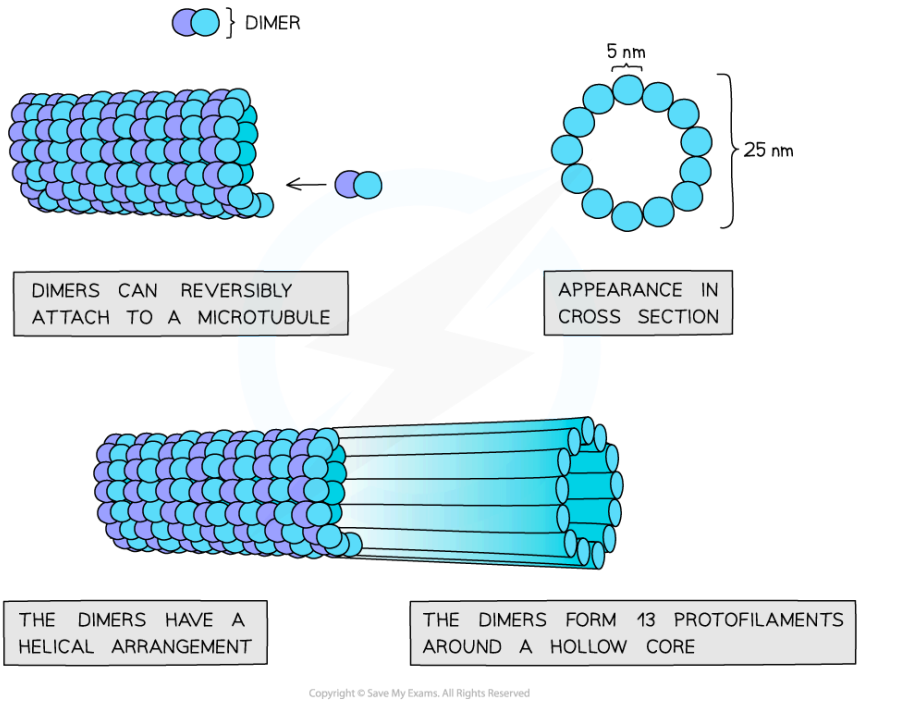
Centrioles are involved with the movement of chromosomes during cell division

Microtubules

- Microtubules are hollow tubes made of tubulin protein
  - α and β tubulin proteins combine to form dimers, which are then joined into protofilaments
  - Thirteen protofilaments in a cylinder make a microtubule
- Microtubules make up the cytoskeleton of the cell
  - The cytoskeleton is used to provide support and movement of the cell

Microtubules and cytoskeleton diagram

Your notes


DIMER
5 nm
25 nm
DIMERS CAN REVERSIBLY ATTACH TO A MICROTUBULE
APPEARANCE IN CROSS SECTION
THE DIMERS HAVE A HELICAL ARRANGEMENT
THE DIMERS FORM 13 PROTOFILAMENTS AROUND A HOLLOW CORE
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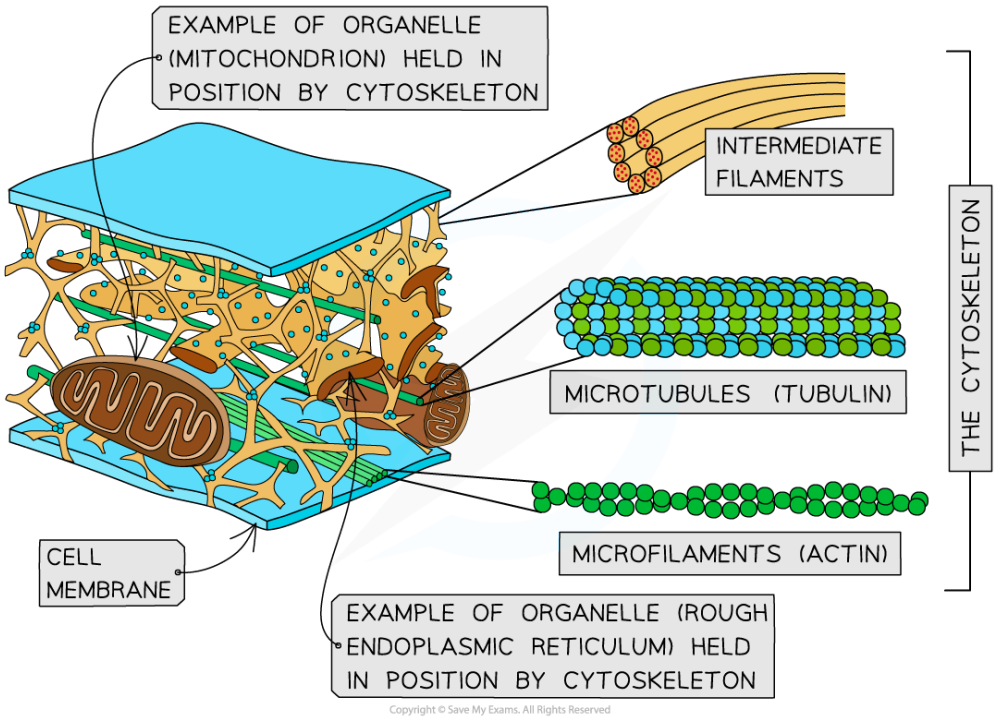
EXAMPLE OF ORGANELLE (MITOCHONDRION) HELD IN POSITION BY CYTOSKELETON
INTERMEDIATE FILAMENTS
MICROTUBULES (TUBULIN)
MICROFILAMENTS (ACTIN)
THE CYTOSKELETON
CELL MEMBRANE
EXAMPLE OF ORGANELLE (ROUGH ENDOPLASMIC RETICULUM) HELD IN POSITION BY CYTOSKELETON
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Microtubules are tubes of protein that are involved with the structure of cell cytoskeletons

Cilia

- Cilia are hair-like projections made from **microtubules**

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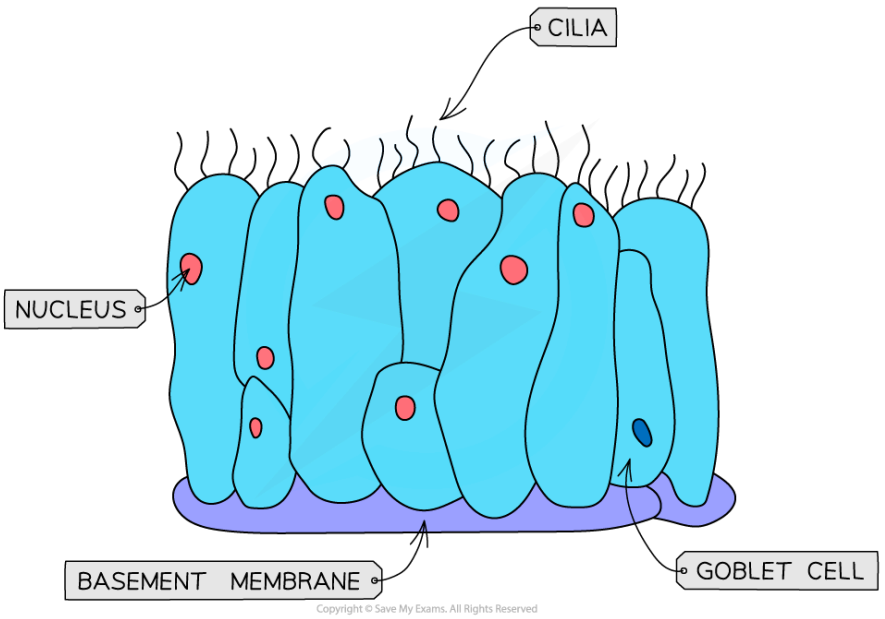
- They can be found of the surface of some cells where they Allow the movement of substances over the cell surface
    - E.g. ciliated epithelial cells in the airways waft mucus away from the lungs



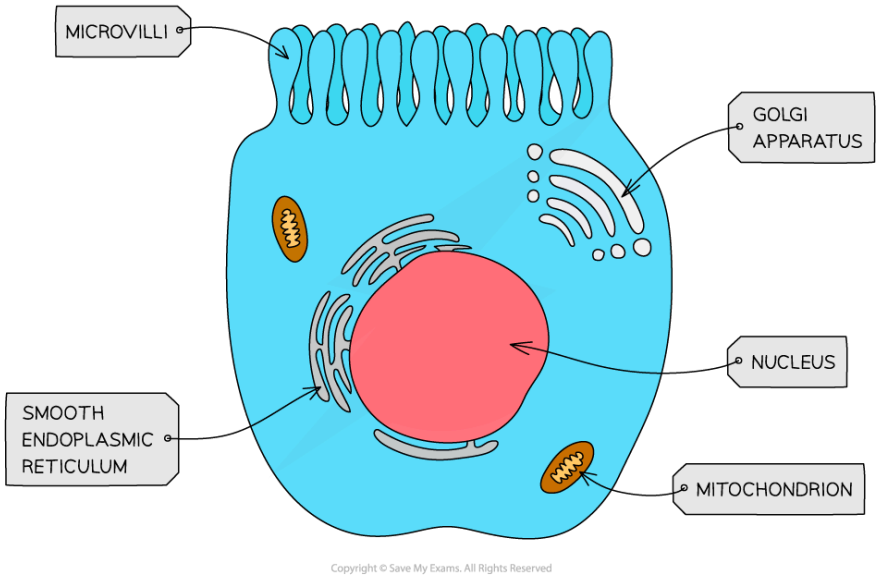
Cilia diagram

Ciliated cells form ciliated epithelium in the airways

Microvilli

- Microvilli are cell membrane projections that increase the **surface area** for absorption
- Microvilli are found in parts of the body that carry out absorption, e.g.
    - The lining of the small intestine
    - The kidney tubules

Microvilli diagram



Microvilli increase the surface area of the cell surface membrane

Your notes

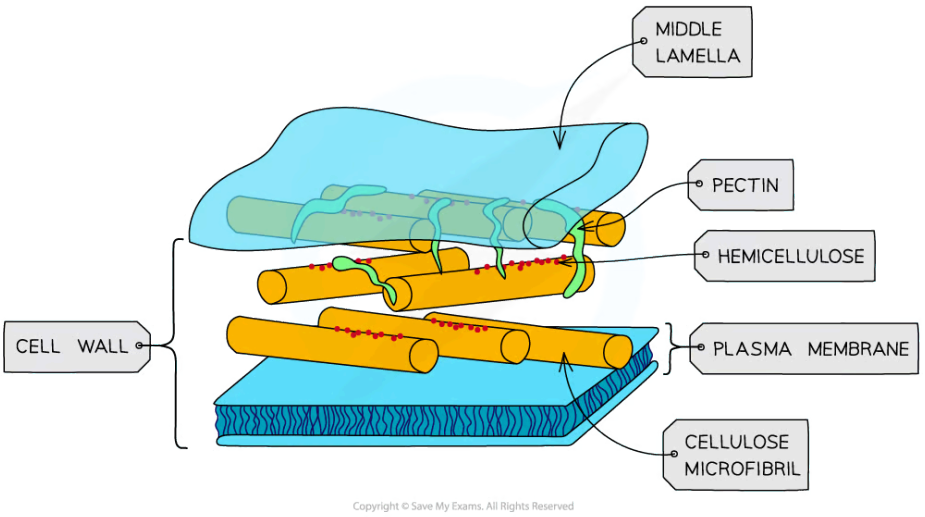
Examiner Tips and Tricks

Be careful not to confuse microvilli with villi. Villi are much larger structures made up of several layers of cells, while microvilli are found on the surfaces of individual cells. Microvilli will be present on the outermost layer of cells that make up the villi!

Cell wall

- Cell walls are outside cell surface membranes and offer **structural support** to some types of cell
  - Structural support is provided by the polysaccharide cellulose in plants, and by chitin in fungi
- Cell walls are freely permeable and do not play a role in controlling the movement of substances into and out of cells

Cell wall diagram

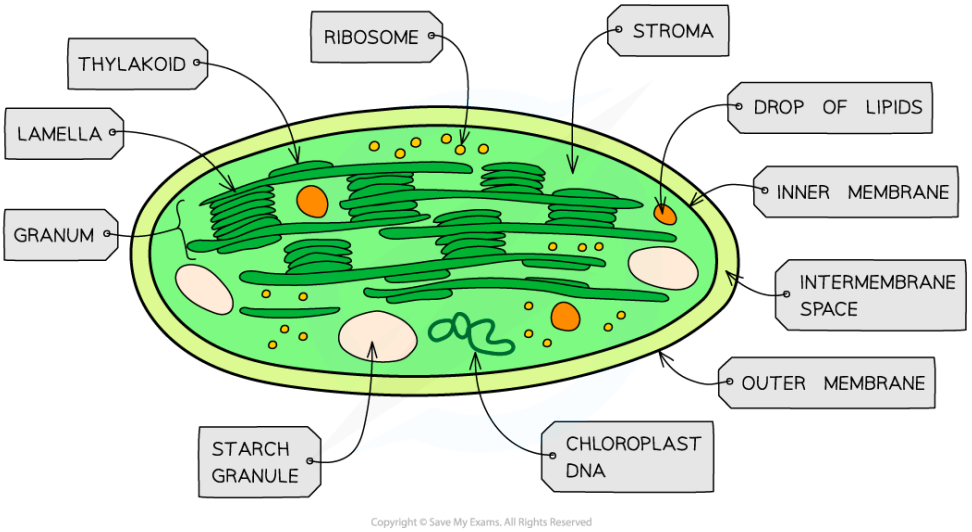


Plant cell walls contain cellulose

Chloroplasts

- Chloroplasts are larger than mitochondria, and are also surrounded by a **double-membrane**
- Membrane-bound compartments called **thylakoids** stack together to form structures called **grana**
- Grana are joined together by **lamellae**
- Photosynthetic pigments such as **chlorophyll** are found in the membranes of the thylakoids, where their role is to **absorb light energy** for **photosynthesis**
- Chloroplasts contain small circular pieces of DNA and ribosomes used to synthesise proteins needed in chloroplast replication and photosynthesis

Chloroplast structure diagram



Your notes

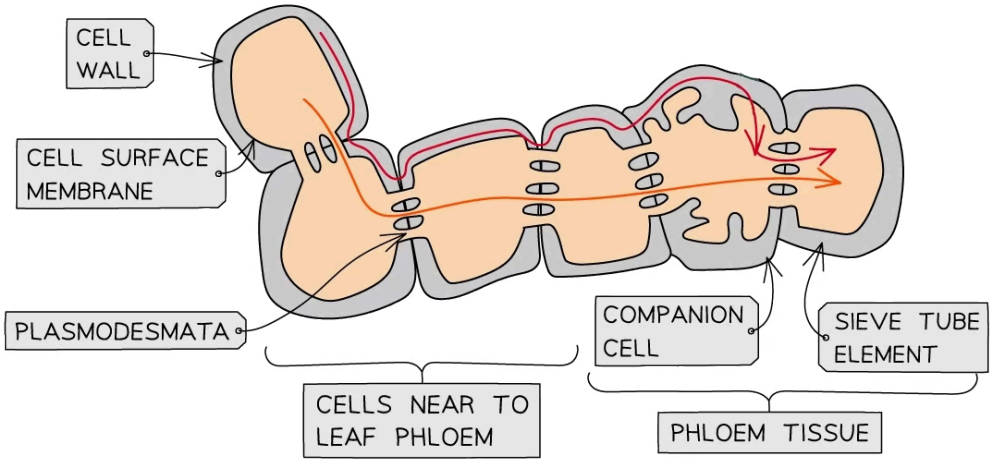
Chloroplasts are found in the green parts of a plant

Your notes

Plasmodesmata

- Plasmodesmata are **bridges of cytoplasm** between neighbouring plant cells
- They allow the transfer of substances between plant cells

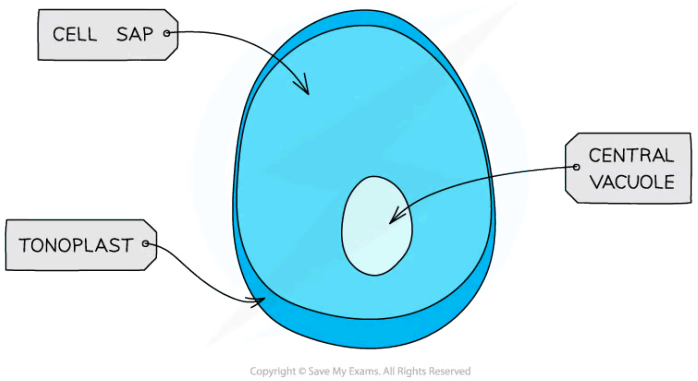
Plasmodesmata diagram



Plasmodesmata mean that the cytoplasm of neighbouring plant cells is continuous; this allows substances to move easily between cells, e.g. sucrose can move easily from the surrounding cells into the phloem

Large permanent vacuole

- Large permanent vacuoles are found in plant cells, where they store **cell sap** and provide **additional structural support** to cells
  - Vacuoles are sometimes found in animal cells, but these will be small and temporary
- Vacuoles are surrounded by the **tonoplast**, which is a partially permeable membrane

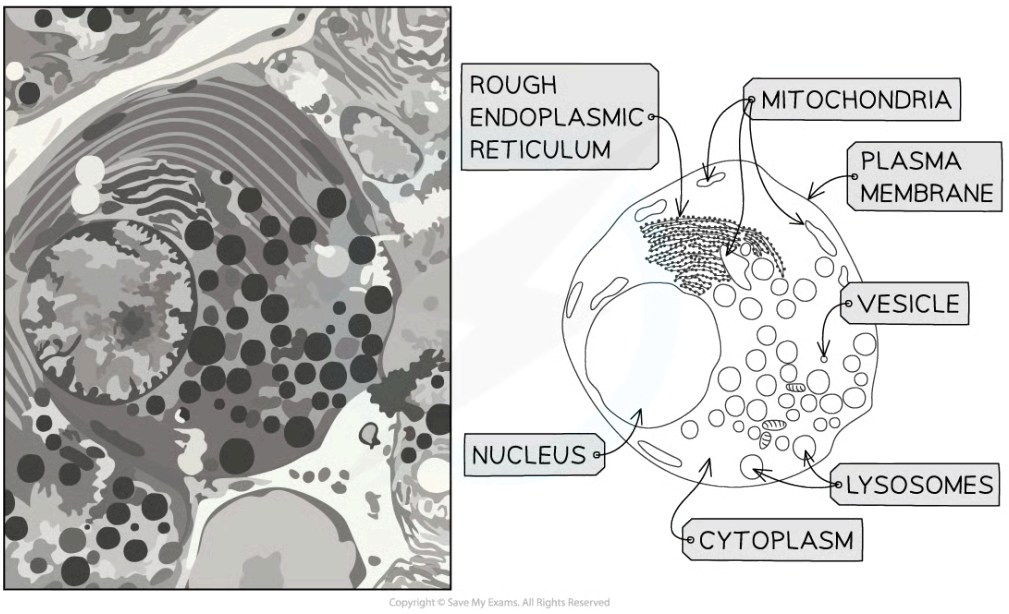


Large permanent vacuoles store cell sap inside plant cells

Your notes

Electron Micrographs: Animal Cells

- Exam questions will not always contain neat diagrams of cellular structures, but may instead present images taken using microscopes
  - Such images are known as **micrographs**
- It is possible to identify organelles in micrographs of animal cells on the basis of their **shape**, **location**, and **size relative to other organelles**, e.g.
  - The nucleus will always be the largest organelle
  - Mitochondria are the next largest, and are often cylindrical with a folded inner membrane
    - Note that mitochondria are not always cylindrical, but can also be circular; their shape will depend on their age, and on the angle at which they were sliced during specimen preparation
  - RER will be near the nucleus, and ribosomes can sometime be seen
  - Lysosomes and vesicles will be smaller than mitochondria



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Exam questions may present micrograph images of cells

Examiner Tips and Tricks

You should be able to describe and interpret photomicrographs, electron micrographs and drawings of typical animal cells.

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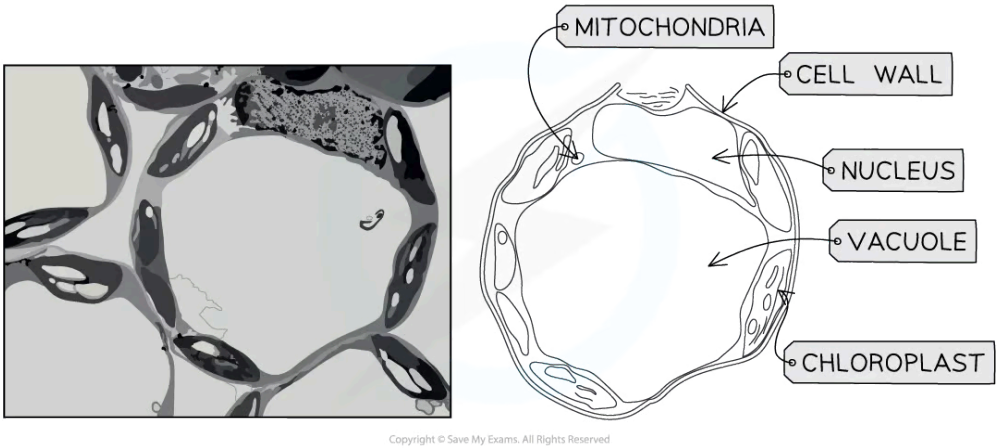
Electron Micrographs: Plant Cells

- Plant cell micrographs can be interpreted using the same techniques as animal cells
  - Large, seemingly empty spaces inside cells will be vacuoles
  - The nucleus will be the largest dark region in the cell
  - Chloroplasts are the next-largest organelles, and grana are often visible



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Vacuoles and chloroplasts can be easily recognised inside plant cells

Examiner Tips and Tricks

You should be able to describe and interpret photomicrographs, electron micrographs and drawings of typical plant cells.

Structure of Animal & Plant Cells

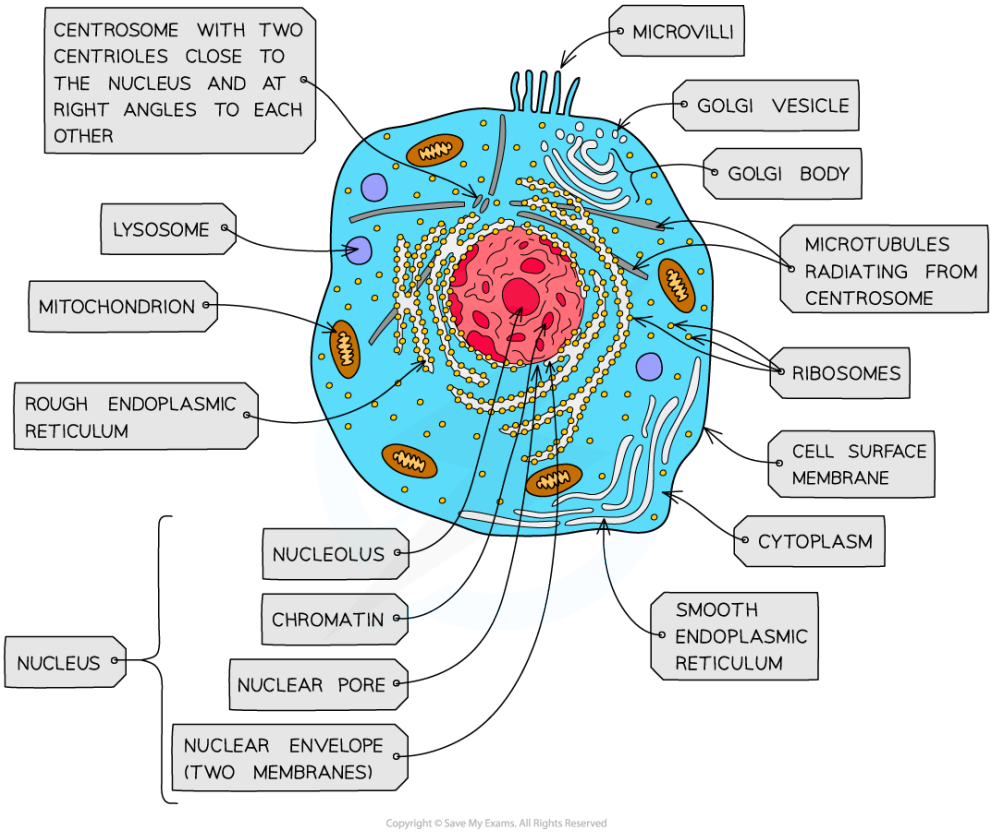
- Animal and plant cells have many common structures:
  - Cell surface membrane
  - Cytoplasm
  - Nucleus
  - Mitochondria
  - Rough and smooth endoplasmic reticulum
  - Golgi bodies
  - Vesicles and lysosomes

- Ribosomes
- Microtubules

- Plant cells are larger and more regular in shape than animal cells, and have the following additional structures
  - Cellulose **cell wall**
  - Large permanent **vacuoles**
  - **Chloroplasts**
  - **Plasmodesmata**

- The only structures found in animal cells but not plant cells are **centrioles** and **microvilli**

Animal and plant cell ultrastructure diagrams



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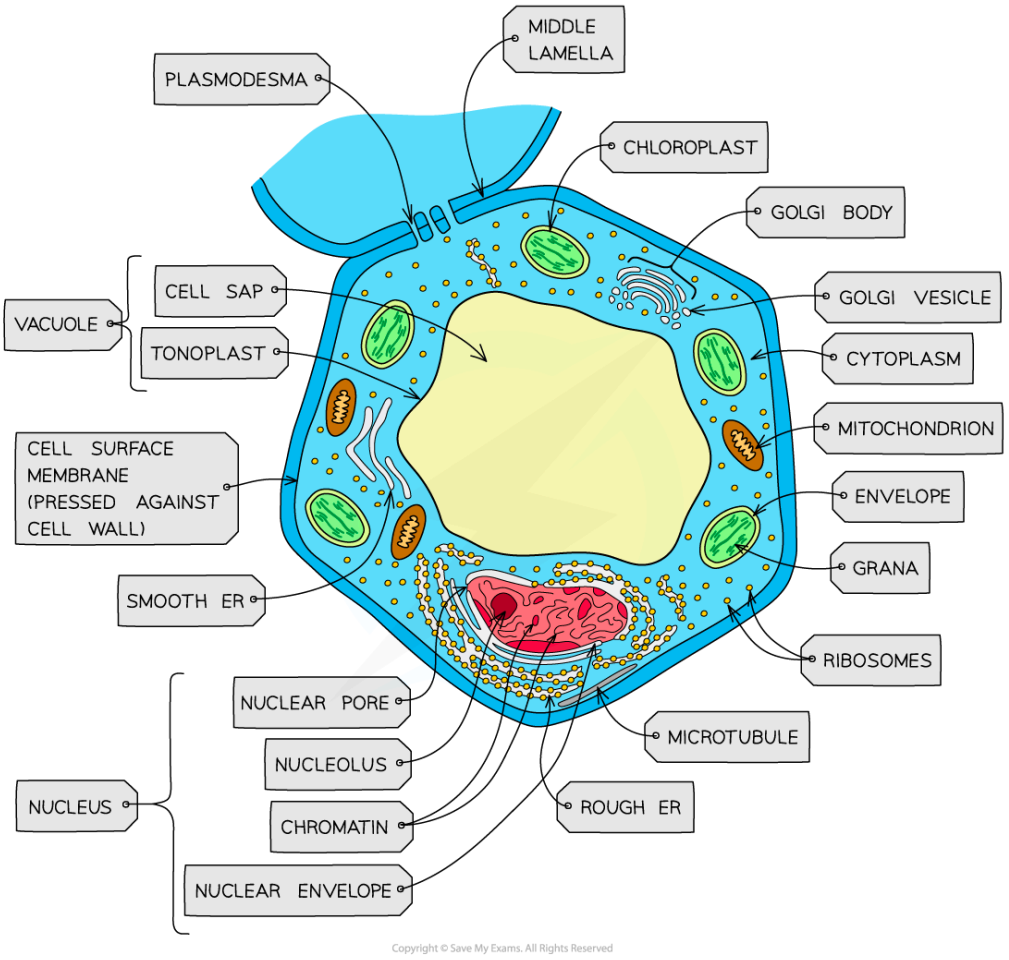


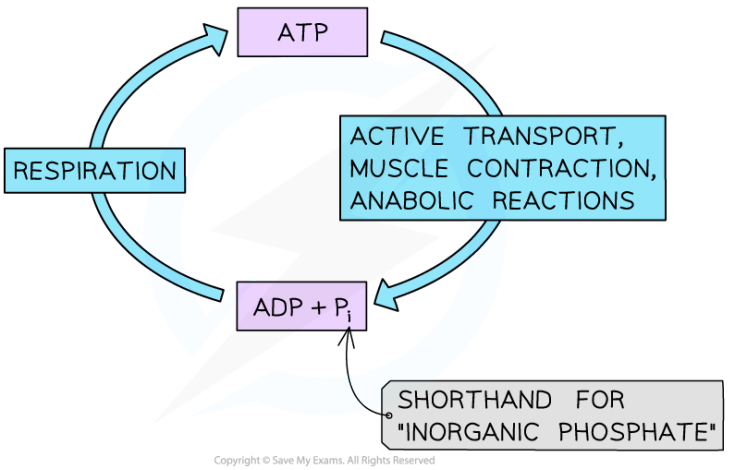
Plant cells have a larger, more regular structure in comparison to animal cells

Your notes

Your notes

The Vital Role of ATP

- All organisms require a **constant supply of energy** to maintain their cells and stay alive
- This energy is required
  - In **anabolic** reactions to build larger molecules from smaller molecules
  - To **move substances** across the cell membrane in active transport, or to move substances within the cell
  - In animals, energy is required
    - For **muscle contraction**
    - In the **conduction of nerve impulses**
- In all known forms of life, ATP from respiration is used to transfer energy in **all energy-requiring processes** in cells; this is why ATP is known as the **universal energy currency**
  - Energy is released from ATP when it is broken down to ADP and inorganic phosphate
  - This process is reversed during **respiration** to make ATP and maintain a supply of energy
- **Adenosine Triphosphate (ATP)** is a nucleotide
  - The monomers of DNA and RNA are also nucleotides



ATP is the energy currency of cells

Your notes

Structural Features of Typical Prokaryotic Cells

- Animal and plant cells are eukaryotic cells, whereas bacterial cells are **prokaryotic**
- Prokaryotes have a cellular structure that is distinct from eukaryotes:
  - Their **genetic material** is free in the cytoplasm and is **circular**
    - Eukaryotic genetic material is packaged as linear chromosomes in the nucleus
  - Prokaryotes **lack membrane-bound organelles**
    - This means that they do not have any internal structures surrounded by membrane, e.g. a nucleus or mitochondria
  - They are many times smaller than eukaryotic cells
    - Prokaryotic cells are usually **1–5 µm in diameter**, while eukaryotic plant cells can be 10–100 µm across
  - Their **ribosomes** are structurally smaller (70 S) in comparison to those found in eukaryotic cells (80 S)
  - Their cell walls are made of **peptidoglycan** rather than cellulose or chitin
- Prokaryotes are always **unicellular**, while eukaryotic animal and plant cells can function together in multicellular organisms

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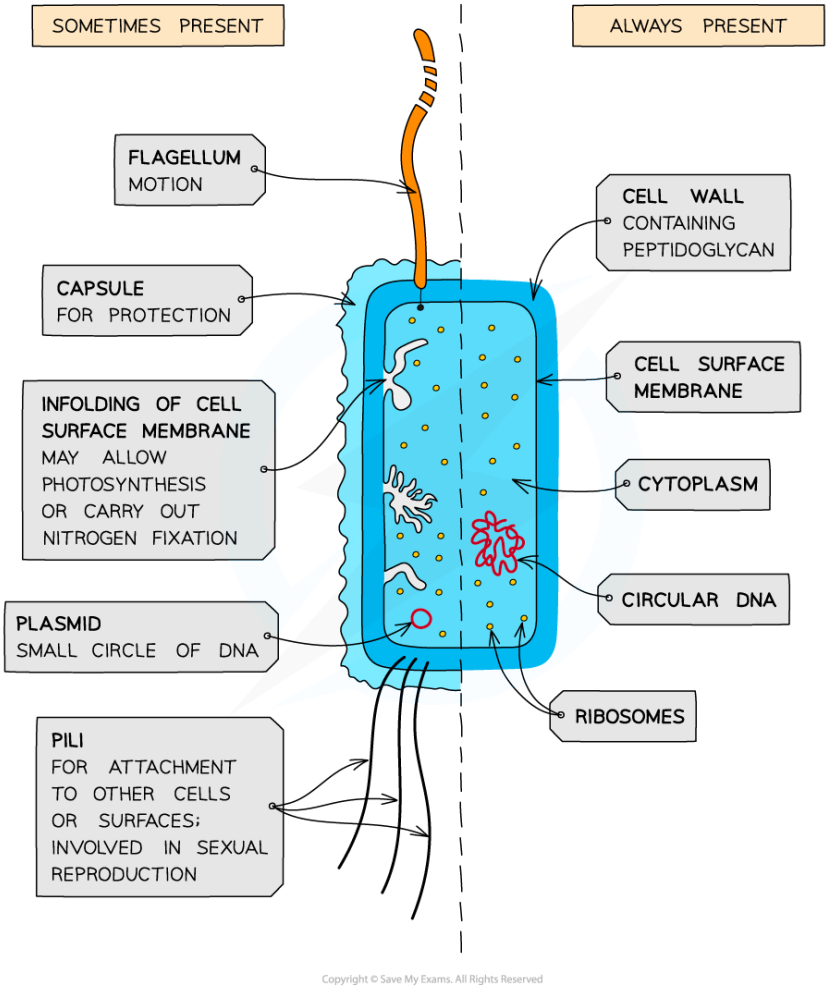

Prokaryotic cells have no internal membrane-bound structures, and are smaller than eukaryotic cells

Prokaryotic v Eukaryotic Cell Structures

Comparing prokaryote and eukaryote cell structure table

Feature	Prokaryotes	Eukaryotes
Size	0.5–5 μm	Up to 100 μm
Genetic material	Circular chromosome in the cytoplasm Not associated with proteins	Linear chromosomes in the nucleus Associated with histone proteins

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Cell division	Binary fission No spindle fibres involved	Mitosis or meiosis Chromosomes are separated by spindle fibres
Ribosomes	70S	80S
Organelles	No membrane-bound organelles	Multiple membrane-bound organelles, e.g. a nucleus, mitochondria, chloroplasts
Cell wall	Made of peptidoglycan	Made of cellulose in plants, or chitin in fungi

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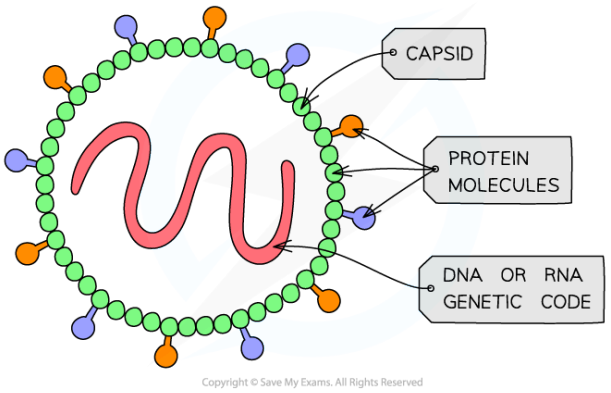
Key Features of Viruses

- **Viruses** are **non-cellular particles** that infect living cells
  - Note that viruses are not cells, and they are not considered to be living organisms, so are referred to as 'particles'
- They are much smaller than prokaryotic cells, with a diameter of 20–300 nm
- Structurally they have
  - A **nucleic acid core** made of either DNA or RNA
  - A **protein** coat called a **capsid**
- Some viruses have an outer layer called an envelope; this forms from the **membrane phospholipids** of the host cell in which they were produced
- Viruses can only reproduce by **infecting living cells** and using their protein-building machinery to produce new viral particles
  - Viruses use attachment proteins on their surface to bind to and infect their host cells

Virus structure diagram



Basic virus structure includes a protein capsid and a nucleic acid core